Remarks

The specification has been amended at page 3 to specify the meaning of the terms PCI, ISA, and AMR. While Applicant submits that the terms "PCI, ISA, and AMR" are readily understood by those skilled in the art, the full names for those terms have been inserted to expedite allowance. As they are now fully defined in the specification, no amendments are necessary in the claims with respect to those terms.

The specification has also been amended at pages 5 and 6 to correct typographical errors. Chemical names for the trademarked materials listed on page 10 have been inserted.

Claims 1-9, 17-21, and 25-27 have been cancelled without prejudice to the filing of continuing applications. In particular, these claims have been cancelled consistent with Applicant's election of the claims of Group II.

Claim 10 has been amended such that the edge connectors have a maximum contact resistance of about $70 \times 10^{-3}\ \Omega$ and such that the conductive ink comprises a thermoset epoxy binder, graphite powder, carbon black, and silver flakes, and wherein the silver flakes have an average size not greater than about 10μm. Support for these amendments is found in the specification as originally filed. For example, support for the thermoset epoxy binder is found at page 5, line 2; and support for the

contact resistance is found at page 5, line 11. Claim 13 has been amended to properly depend from claim 12. Claim 14 has been amended to indicate the material that was previously described by a trademark. Thus, no new matter has been added by any of the amendments made herein.

The specification has been objected to and claims 10-12 have been rejected as being indefinite pursuant to 37 C.F.R. § 112, second paragraph because they recite, as units for sheet resistivity, Ω/sq/15μm. Applicant submits that these units are clear and well known to those skilled in the art; they do not render the claims indefinite. The Applicant has enclosed as Appendix 1 hereto a section of "Thick Film Technology and Applications", Electrochemical Publications, Ltd., Isle of Mann, British Isles, 1997, by Malcolm Haskard and Keith Pitt that explains how sheet resistivity is determined. The Examiner's attention is directed to page 3, line 4, through the end of page 5. As discussed there, the resistor depicted in Figure 1.5 has a resistance calculated using Equation 1.1:

$$R = \rho \bullet \frac{L}{tW}$$

In situations where the length and the width of the resistor are the same, i.e., the resistor is a square, the resistivity ρ is defined as Ω/sq. In the rejected claims, the resistivity is presented for a given thickness, 0.15 μm.

The use of these units to define sheet resistivity is also explained in pages 40-43 from a chapter titled Thick-Film Design Guidelines, a copy of which is attached hereto as Appendix 2. Unfortunately, the Applicant has not been able to determine the title, author or other information about the book from which this chapter is excerpted. Applicant is certain the book was published earlier than one year before the filing date of this application. It is quite clear from that chapter that the use of "Ω/sq/15μm" is common in the art and its use in the claims does not render the them indefinite. As is explained on page 40, sheet resistivity is determined as bulk resistivity, ρ, times length, divided by the cross-sectional area. Again, where the length and width are equal, the units for sheet resistivity simplifies to Ω/sq/thickness, in this case, 15μm.

Consequently, there can be no question that the units for sheet resistivity used in the claims are well understood to those skilled in the art. The person skilled in the art would certainly know what Ω/sq/15μm means. Thus, claims 7 and 17 are not indefinite.

The term "grind" in claims 15, 16, and 17 is correct and intended by Applicants.

The claims also stand rejected under 35 U.S.C. § 103(a) as being rendered obvious by Research Disclosure (June 1989, no.

302.) or Applicant's admitted start of the art (page 2 of the specification) in combination with U.S. Patent No. 4,545,926 (Fouts et al.) or information from Methode Development Co. pertaining to Goldstone #3000 conductive overprint ink ("Gold Substitute"). Contrary to the Examiner's argument, these references, taken alone or in combination, do not render the claimed invention obvious.

The teachings of Fouts et al. and Gold Substitute together with Research Disclosure or Applicant's admitted prior art do not render the present invention obvious to a person of ordinary skill in the art, taken alone or in combination. In reviewing obviousness rejections, the Federal Circuit has stated that where claimed subject matter is rejected as obvious in view of a combination of references, "a proper analysis under § 103 requires, *inter alia*, consideration of two factors: (1) whether the prior art would have suggested to those of ordinary skill in the art that they should make the claimed composition or device, or carry out the claimed process; and (2) whether the prior art would also have revealed that in so making or carrying out, those of ordinary skill would have a reasonable expectation of success." In re Vaeck, 947 F.2d 488, 493, 20 U.S.P.Q.2d 1438, 1442 (Fed. Cir. 1991). The Federal Circuit emphasized that "[b]oth the suggestion and the reasonable expectation of success

must be found in the prior art, not in the applicant's disclosure." Id.

First, the claims require that the maximum resistance across the edge connector be about 70 x 10^{-3} Ω. This maximum resistance is nowhere suggested by the discussion of the prior art in the specification on page 2, or the Fouts et al., Gold Substitute or Research Disclosure references. If anything, it seems that Fouts et al. teaches a much greater maximum resistance.

Second, contrary to the Examiner's position, neither Gold Substitute or Fouts et al. nor Research Disclosure contains the requisite motivation to combine their respective teachings. Third, Gold Substitute or Fouts et al. in view of Research Disclosure does not provide a reasonable expectation of success in making the claimed circuit boards. The second and third points made above are discussed in more detail in the following paragraphs.

Gold Substitute discloses a screenable polymer finish for copper tabs and keyboard pad contacts. There is no disclosure or suggestion in that document of the components required by the claims for the conductive ink. Indeed, there is no discussion at all of what components are used to make the ink. Further, Gold Substitute is completely silent with respect to the maximum resistance across the edge connector of about 70 x 10^{-3} Ω. The

deficiencies in Gold Substitute are not found in any of the other cited references. Thus, there is nothing in the Gold Substitute document indicating that material may be used in the claimed invention.

Fouts et al. relates to conductive polymers having a positive temperature coefficient of resistivity. These compositions exhibit positive temperature coefficient (PTC) behavior. In other words, these compositions "undergo a large increase in resistivity as the temperature increases above a certain level." See the Fouts et al. Abstract and Figures 1-8. Such materials are used to prepare resettable fuses for high current applications. Fouts et al., column 1, line 58.

The Fouts et al. disclosure lacks any suggestion that the disclosed composition can be used as a component of an edge connector. The missing suggestion is not found in Research Disclosure.

Research Disclosure discloses "low cost edge tabs" comprising a "cured resistive ink directly on base metal." In particular, Research Disclosure requires a "<u>special</u> filled polymer resistor ink" printed over copper connector pads. Research Disclosure points out that the ink is special "in that it has the necessary wear resistance and also protects the pad underneath it from the environment. Further, "the electrical path is transverse of the ink layer so that little resistance is

introduced." See Research Disclosure at lines 13-18. However, Research Disclosure is completely silent about what components are found in the ink. The document is only a brief description of the objective, low resistance with a sufficient level of durability, to be achieved without any suggestion of how to achieve that goal. What is clear though from this document is that no more than "little resistance" may be introduced by the composition.

The requirement in Research Disclosure of "little resistance" is a clear teaching away from using a material that has a high resistance once a certain temperature is reached. Consequently, the teaching in Research Disclosure cannot be combined with that of Fouts et al. since Fouts does not teach materials that only have low resistance. Put another way, there is no suggestion in either reference to use the material of Fouts et al. in the scheme envisioned by Research Disclosure.

In addition, since Research Disclosure requires a "special" ink without giving any guidance whatsoever as to its components, it cannot be said that the combination of the references yields the necessary reasonable expectation of success. Certainly, assuming arguendo that the references can be properly combined, they do not remotely contain the information necessary for one skilled in the art to judge whether the combination would generate a useful circuit board. The rejection set forth in the

Action does not, therefore, satisfy the criteria outlined by the Federal Circuit for making a prima facie case of obviousness.

For the above reasons, withdrawal of the 35 U.S.C. 103(a) rejection is, therefore, respectfully requested.

Applicants respectfully solicit allowance of the claims as amended and passage of the case to issuance. Should the examiner believe that a discussion of this matter would be helpful, he is invited to telephone the undersigned at (312) 913-0001.

Respectfully submitted,

Dated: February 27, 2004 By: ______________________

Steven J. Sarussi
Reg. No. 32,784

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 South Wacker Drive
Chicago, Illinois 60606
(312) 913-0001

APPENDIX 1

ELECTROCHEMICAL PUBLICATIONS LTD
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was used in any real way in commercial products. IBM, in conjunction with Du Pont, developed a series of pastes based on palladium known as the 7800 series. These pastes were used by IBM in its 360 computer series (Davis *et al.*, 1964). Today the types and range of pastes are many and the versatility and applications of the thick-film technique are growing continually. Figure 1.2 illustrates several thick-film products.

Over the years, the silk-screening process had not been the only method used to produce a film circuit. Vacuum deposition, electroplating, spin-on and etching, painting or spraying and die stamping are examples of alternative processes. Some are still employed today. Vacuum deposition, with or without thickening by electroplating, is today an alternative film process and is called 'thin film'. The names 'thick' and 'thin' suggest that the difference between the two technologies is the thickness of the material laid down. Such is not the case. By and large, a thin-film circuit refers to a ~~circuit deposited~~ by a vacuum deposition (evaporation, sputtering, etc.) process, whereas a thick-film circuit means a screening process has been ~~employed.~~

In this chapter the thick-film process will now be considered in more detail and then compared with the alternative technologies.

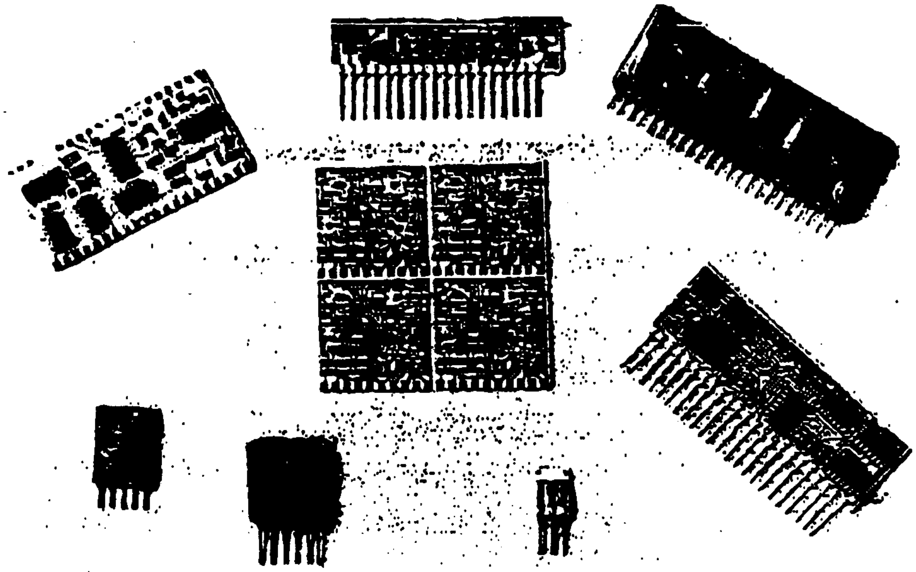

Fig. 1.2 Assortment of thick-film products. (Courtesy of Philips Australia)

1.1 AN OVERVIEW OF THE THICK-FILM PROCESS

The process consists of a number of simple steps which are repeated several times in the correct sequence. These steps are screen manufacture, printing and firing. To these a number of standard electronic processes must be added including cleaning, soldering, electrical test and packaging.

The basic step to the process is the screening. It is the same process that has been used by the printing and fabric-making industries for generations. The inks, or pastes here, are pushed through a screen by a squeegee, made of a pliable material. Only where there are holes in the screen will the paste come through. Thus the pattern on

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Let us consider the manufactur
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Before production can occur,
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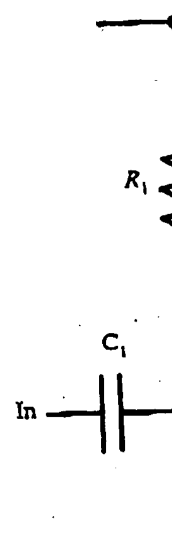

Fig. 1.3 Circuit t

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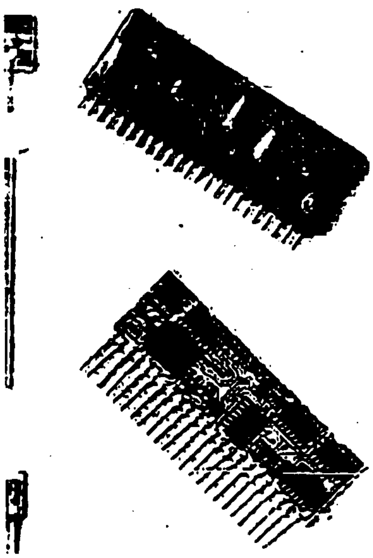

Courtesy of Philips Australia)

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, made of a pliable material. Only
come through. Thus the pattern on

the screen defines the resultant pattern printed on the substrate. Since an electrical circuit is to be printed, the substrate must be an insulator such as alumina, polyester (for polymer pastes) or porcelain-coated steel.

Let us consider the manufacture of the simple transistor circuit given in Figure 1.3. Because the transistor cannot be screen-printed, it must be added as a discrete surface-mounted component or silicon die, later to be wire bonded out.

Before production can occur, the circuit must be produced as a two-dimensional layout which defines where conductor tracks run, the size, shape and position of resistors and capacitors, allowing space for pads of appropriate size for external connections and the mounting of chip components including semiconductor devices (Figure 1.4(a)). The layout consists of several layers, a layer being required for each different paste type. Thus there will be a lower conductor paste layer, resistor paste layer, insulator paste layer and second upper conductor paste layer, the last two necessary to form the capacitor. Consequently, this circuit would require four screens, one for each layer (Figure 1.4).

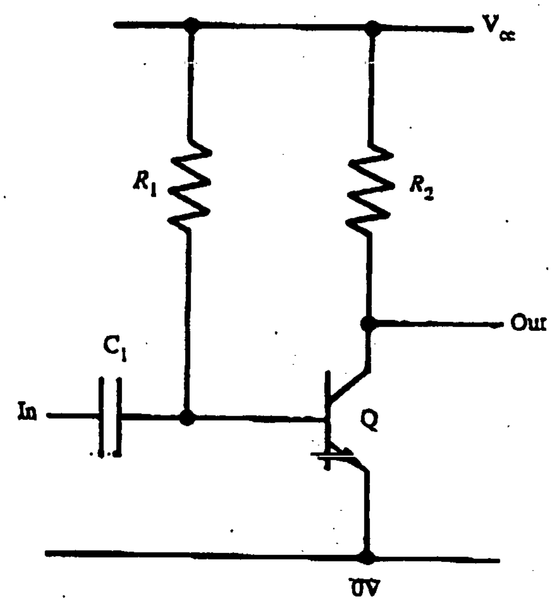
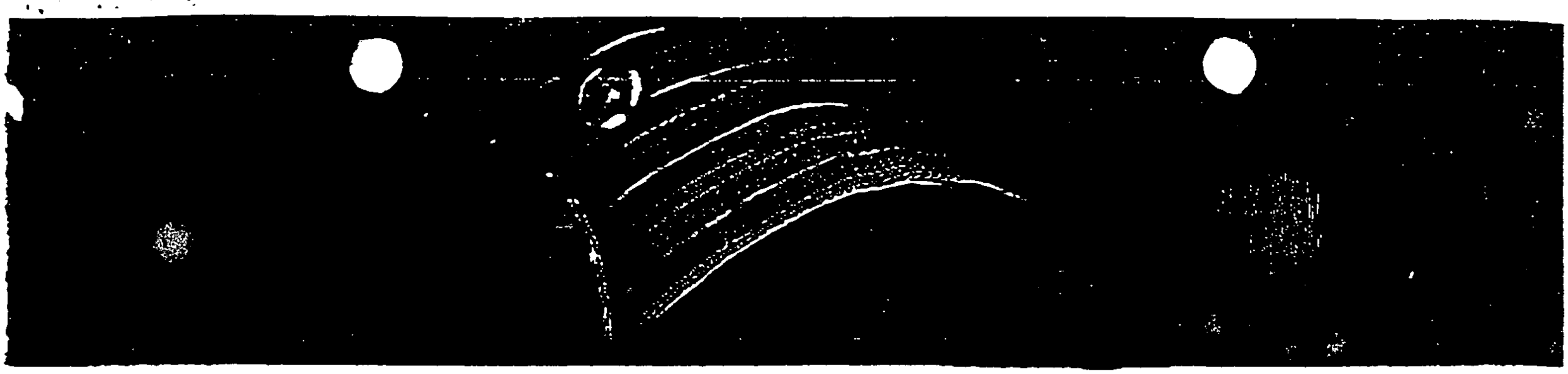


Fig. 1.3 Circuit to be fabricated to illustrate the thick-film process.

The physical size of the resistors is calculated from the property of paste to be used, called 'sheet resistance'. This term allows the transformation of a three-dimensional process into one that is two-dimensional or planar. The assumption is that the screen-printing process will always print a constant thickness.



Hence, a resistor of dimensions shown in Figure 1.5 has a resistance R given by:

$$R = \rho . \frac{L}{tW}$$

$$= R_s . \frac{L}{W} \qquad (1.1)$$

where:

$R_s = \frac{\rho}{t}$

ρ is the bulk resistivity of the paste material
t is the constant thickness

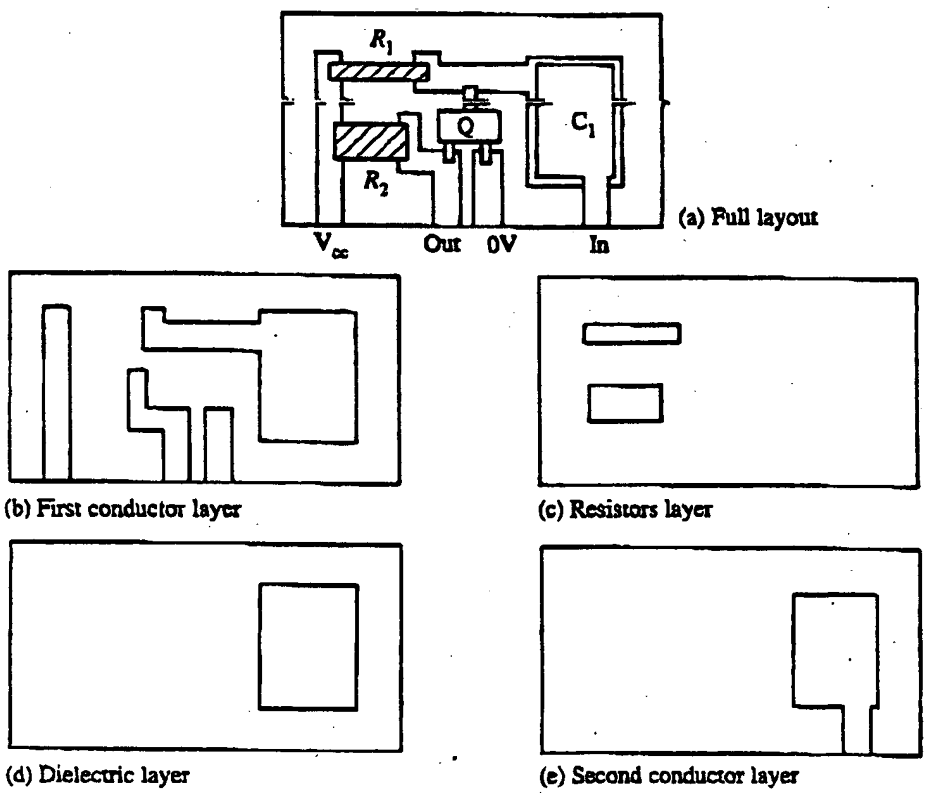


Fig. 1.4 Layout of the simple transistor amplifier.

R_s is called the sheet resistance of the paste. To determine the size of an L and W for a given resistor (say R_1), if R_1 is greater than R_s one needs a long resistor, therefore W will be the smaller dimension. By making W the minimum dimension the process allows (assuming other factors like dissipation do not cause a problem), one can now

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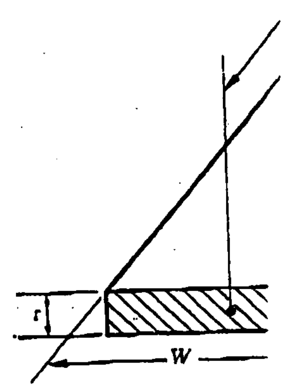

Fig. 1.

In order to produce the circuit
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2 The first conductor is printed.
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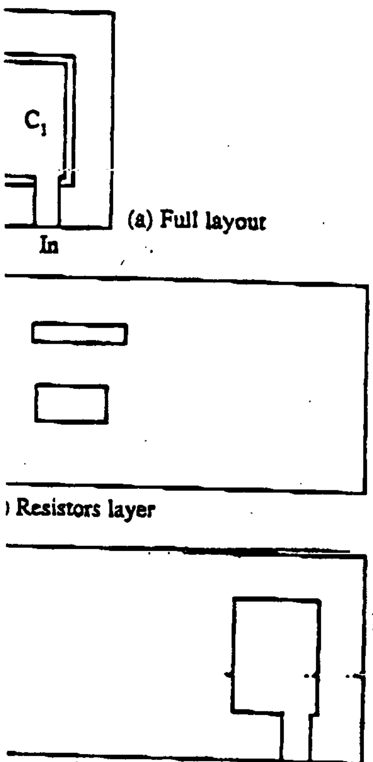
(1.1)



(a) Full layout

) Resistors layer

Second conductor layer

sistor amplifier.

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minimum dimension the process
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design a resistor of the correct value of minimum p[...]le dimensions. That is, knowing R_1, R_s and W, L can be calculated from Equation (1.1). Should R_1 be less than R_s, then L will be the smaller dimension, to be made the minimum value set by the process, and W can then be calculated.

For the capacitor, if the printed thickness of the dielectric is constant, then a given dielectric paste has a fixed capacitance per unit area. For a known capacity value requirement C_1, the area can now be computed. It will be seen later that a chip capacitor is often preferred to a printed one. However, in this example one will be printed to illustrate the process more fully.

Returning to the resultant artwork for each of the four layers, they are next transferred to a mesh screen by a photographic process. The mesh of plastic or stainless steel is tightly stretched over a frame. Using a light-sensitive, thick emulsion coating on the screen, and exposing the screen through actual size positives of the artwork to ultra-violet light, the portions of the emulsion where printing is not to occur are polymerised by the light and do not dissolve away during the development stage. The resulting screens, one for each layer, will define the areas to be printed, as they are covered with emulsion (preventing any paste from being squeezed through except for the small section defined by the original artwork) and photographically removed.

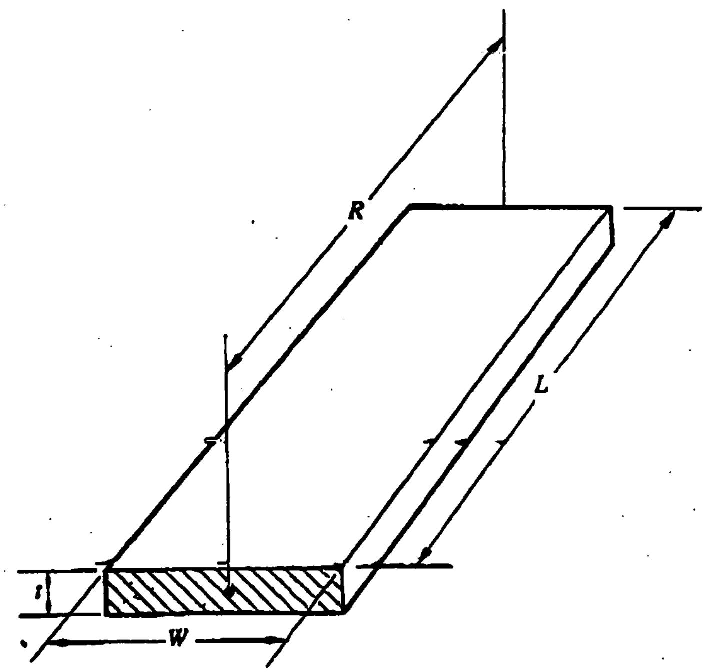

Fig. 1.5 Dimensions of a resistor.

In order to produce the circuit of Figure 1.3, the thick-film process would proceed as follows:

1 The four screens must be made.
2 The first conductor is printed, allowed to settle and dry, and then fired so that it can be transformed to its final composition.

3 The dielectric is printed, dried and fired. The dielectric is processed before the resistors, as the firing temperature is often higher. Two printings of dielectric are normally undertaken to ensure there are no pinholes to cause a short circuit.
4 The upper conductor is printed, dried, but not necessarily fired.

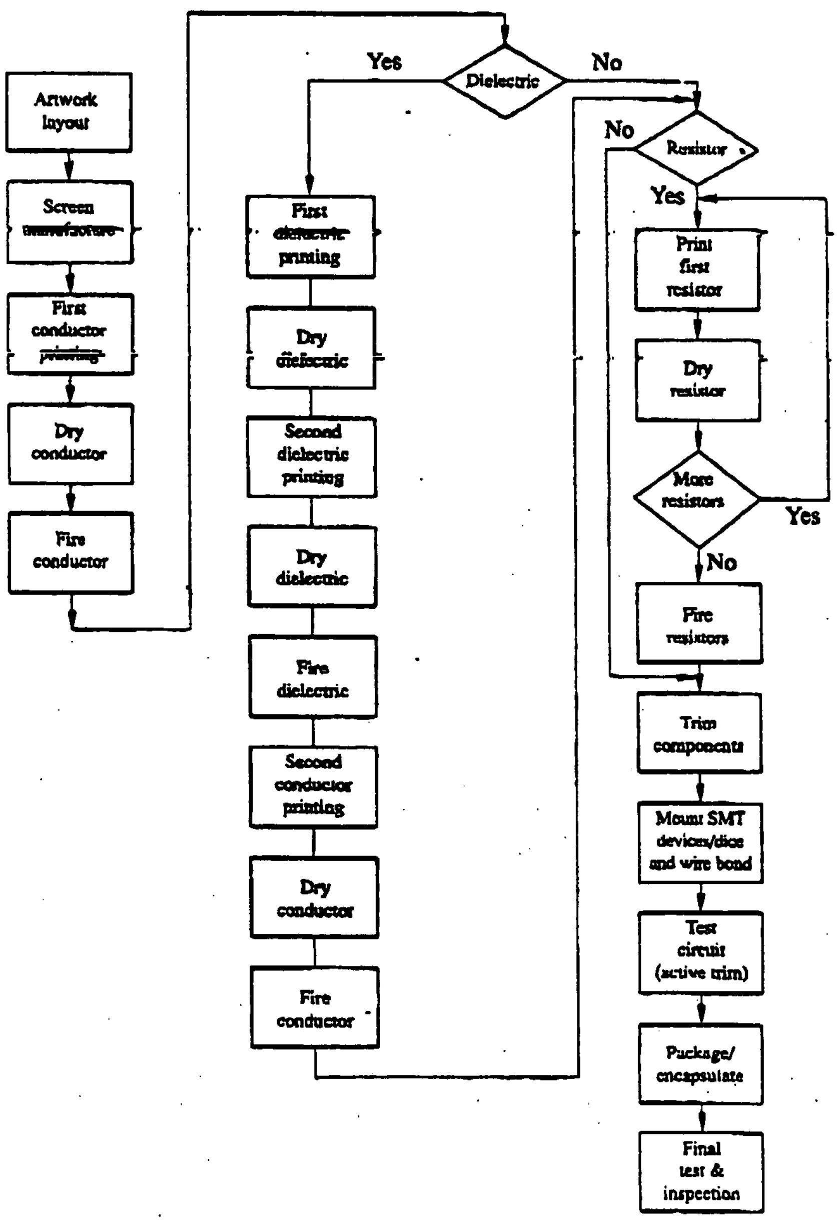

Fig. 1.6 Summary of a typical thick-film process.

5 As each firing may cause a ch resistors as late as possible in a with the conductor. Should the employed. Similarly, separate f dielectric layers.

While this completes the pri complete the product. If the ±2(resistors can be trimmed (upward a laser or an air abrader. Next, th mounted by soldering it in place satisfactorily, can be packaged or and product branding complete th

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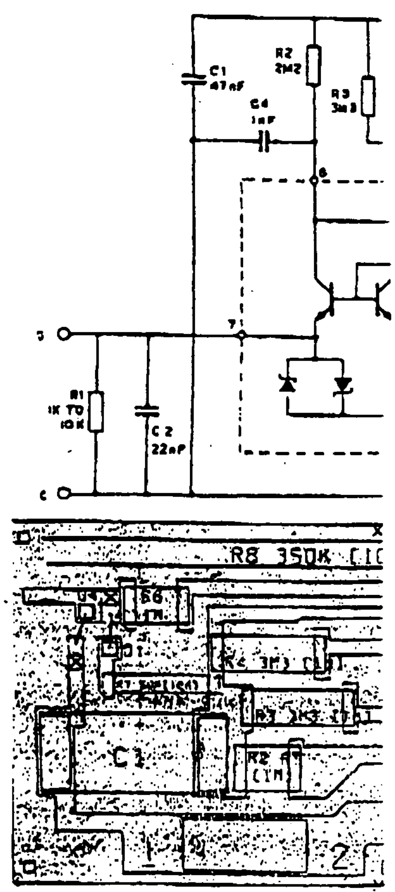

Fig. 1.7 Circuit diagram and thick-
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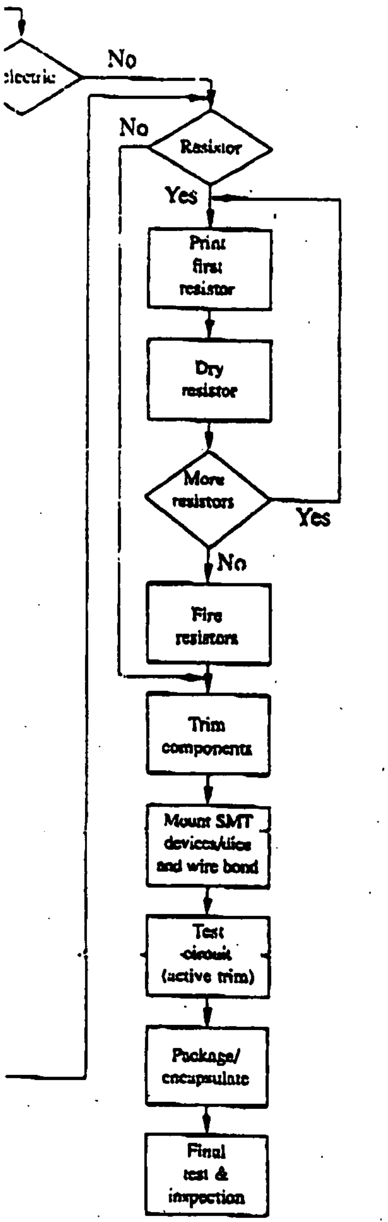

ick-film process.

5 As each firing may cause a change in the sheet resistance, it is good policy to fire resistors as late as possible in a process. The resistors are printed, dried and co-fired with the conductor. Should the pastes not allow co-firing, separate firings must be employed. Similarly, separate firings may occur after the printing of each of the two dielectric layers.

While this completes the printing process, various other steps are required to complete the product. If the ±20% printing tolerance of the resistors is too large, resistors can be trimmed (upwards only) in value by removing some of the paste, using a laser or an air abrader. Next, the small outline package transistor must be surface-mounted by soldering it in place. The circuit can then be tested and, if it performs satisfactorily, can be packaged or encapsulated in a dip plastic. A final inspection, test and product branding complete the manufacturing process.

Figure 1.6 is a flow diagram of a more general thick-film process allowing several options, while Figure 1.7 is the circuit diagram and layout of a thick-film product.

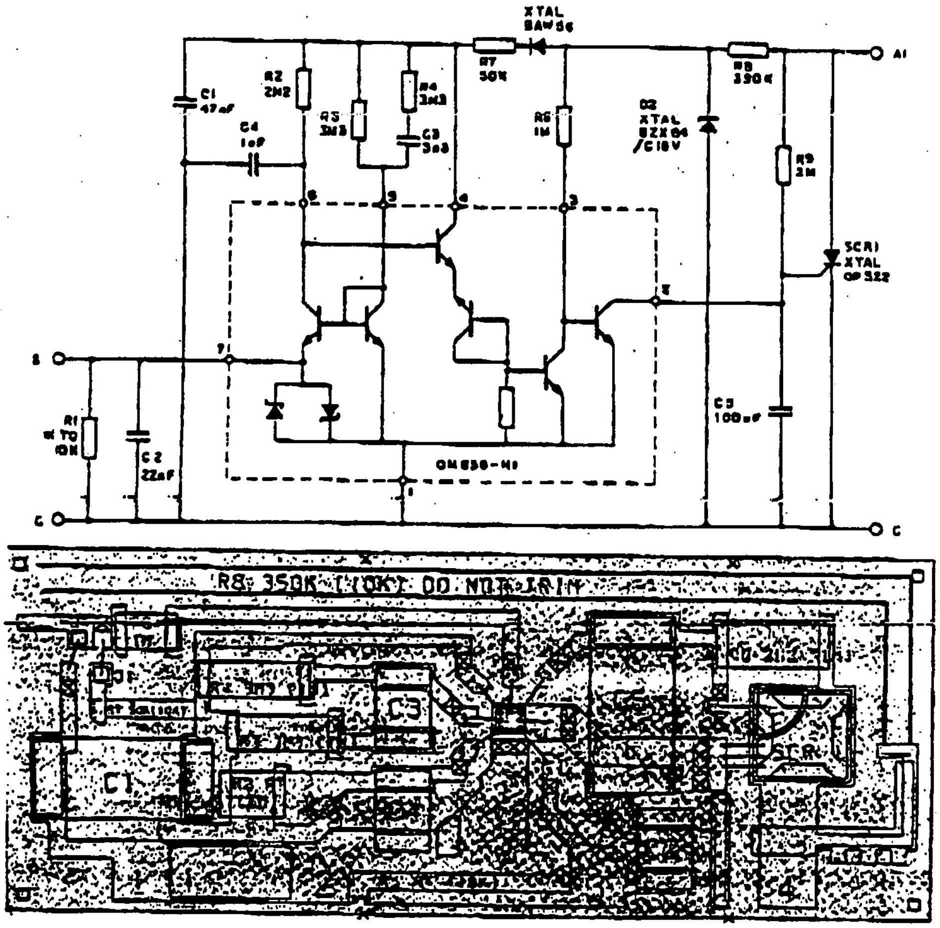

Fig. 1.7 Circuit diagram and thick-film layout design for a commercially available product. (Courtesy of Philips Australia)

APPENDIX 2

4.3 BASIC DESIGN RULES FOR THICK-FILM RESISTORS

Description of Thick-Film Resistors

As described in Chapter 3, the resistors are obtained by screening and firing resistive pastes on to a ceramic substrate. This resistor shown in Figure 4.4 can be considered as a conductive block of uniform thickness T, width W, and length L.

If the bulk resistivity (resistance per unit volume) of the material is ρ (Ω/cm), then the resistance R measured across the block in direction of the length L is given by

$$R = \frac{\text{bulk resistivity} \times \text{length}}{\text{cross-sectional area}}$$

$$= \frac{\rho L}{TW}$$

If ρ/T in this expression is now defined as the sheet resistivity, ρ_s, then

$$R = \rho_s \frac{L}{W}$$

or

$$R = \rho_s \times \text{number of squares}$$

where L/W is the number of squares in the direction in which the resistance is being measured.

The sheet resistivity is defined in ohms per square, and is the basic design parameter specified for film resistors, both thick and thin film.

Example If the resistor is screened with paste of sheet resistivity 1000 Ω per square, and the resistor is defined as 0.200 in. long and 0.040 in. wide, then the resistance R is given by

$$R = 1000 \frac{\Omega}{\text{square}} \times \frac{0.200 \text{ in.}}{0.040 \text{ in.}} \text{ squares} = 5000\ \Omega$$

It is important to note that for any given film of constant thickness, increasing the length and width by equal ratios will not alter the resistance value. For example, a 40 × 40 mil resistor has the same value as a 100 × 100 mil resistor. They both have the dimensions of 1 square. The sheet resistivity of a thick-film paste is determined by screening and measuring a resistor of unit length and width. Resistor paste manufacturers specify sheet resistivity for a specified thickness T, and obtain different sheet resistivities by altering the resistive paste material composition. Most resistive pastes are specified at about 0.8 to 1.0 mil thickness.

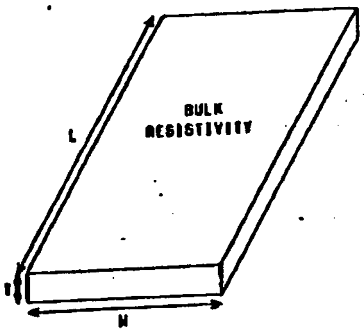

FIGURE 4.4. Sheet resistivity of a thick-film resistor.

Resistor Design Guidelines

The *aspect ratio* of a thick-film resistor is the ratio of the resistor's length to width. This aspect ratio should not be greater than about 20:1 or less than about 1:3. Rather than design resistors with long thin aspects or short wide aspects it is usually more convenient and area saving to change to a different sheet resistivity. For example, rather than designing a 1-MΩ resistor with 100 squares of a 10-kΩ per square paste, it is easier to design it with 1 square of 1-MΩ per square paste.

However, since a separate piece of artwork, a separate screen, and a separate screening operation are required for each resistor paste, it is important to select the inks to minimize their number and optimize the aspect ratios of the resistor. Wherever possible, the number of resistor pastes should be kept to two or three. If resistors are required on both sides of the substrate, care should be taken to partition inks of the same resistivity to the one side. This will again minimize the number of screens and screenings. Other requirements, such as power dissipation, tracking requirements, and voltage stress, may well determine the resistor geometry. Resistor pastes are available with sheet resistivities from 1 Ω per square to 10-MΩ per square in decade steps. Pastes can be blended to give intermediate sheet resistivities if required, although for reasons of economy and inventory control the number of blends should be minimized. The minimum dimensions of resistors are 20 mils wide and 30 mils long, although twice these dimensions is desirable if stability is required. Figure 4.5 shows typical resistor geometries and dimensions for a subsquare and a multi-square resistor. As a rule of thumb the power density should be kept

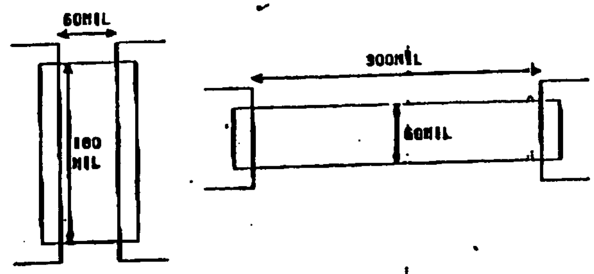

FIGURE 4.5. Thick-film resistor geometries.

below 50 W/in.^{2} and the voltage stress below 1 V/mil. The total dissipation of resistors plus active devices should not exceed about 1 to 2 W/in.^{2} of substrate area.

If the number of squares required is very large, and for some reason a higher sheet resistivity is not available to reduce the square count, then a zigzag (meander) resistor configuration can be used as shown in Figure 4.6.

When calculating the square count of a zigzag resistor, each corner should be counted as approximately 1/2 square. For example, the zigzag resistor shown in Figure 4.6 would be of 39 squares.

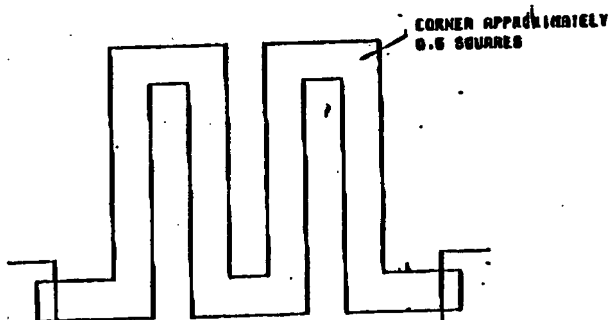

FIGURE 4.6. High-square count resistor geometry (39 squares).

Resistor Tolerances

Due to variances in materials, screened thickness, and resistor definition, the typical as-screened value of a thick-film resistor will be approximately ±20%. Resistors requiring only ±20% tolerance or greater should be designed in the layout stage to nominal value. If resistors are required with less than 20% tolerance, they should be designed in the layout stage to 80% of nominal value or less. The resistors will then need to be sand or laser trimmed to value after firing. The trimming process and procedures are described in detail in Chapter 7.

Resistors will increase in value during trimming and sufficient trim ratio needs to be available in the designed resistor. A trim ratio can be defined as

$$\text{trim ratio} = \frac{\text{number of layout squares after maximum trim}}{\text{number of layout squares before trim}}$$

Example Consider a resistor with required final value of 10 squares designed with a ±20% process. The initial layout would be for 20% less squares, or 8 squares. The process could now come in at minus 20% in the worst case, giving an as-figured value of 6.4 squares. To adjust this resistor back to 10 squares, we would need to add 3.6 squares. But each resistor square added is 20% low. Hence we need a trim capability of 3.6/0.8 squares = 4.5 squares. Thus the

$$\text{trim ratio (20\% process)} = \frac{8 + 4.5}{8} = \frac{12.5}{8}$$

$$= 1.56$$

The resistor would therefore be laid out as 8 squares with 56% × 8 squares = 4.48 squares possible trim variation. Because of the loose tolerances involved, the possible trim variation would be rounded up to 4.5 or even 5 squares.

Resistor Trim Geometries

To achieve the trim ratios required, various resistor trim geometries and trim cuts are available. Some of the popular trim configurations are shown in Figure 4.7. Care must be taken in the layout stage such that after trimming the resistor does not violate any of the basic design guidelines, such as 20-mil minimum material width. Violation of these guidelines may lead to hot spots due to current crowding in the resistor, with loss of stability and possible resistor failure. With this in mind it should be obvious that a top hat, for example, should be at least 40 mil wide. For ease of trimming resistors should, where possible, be oriented in the X-Y direction.